MOLLUSCAN FAUNAS OF THE EARLY PLEISTOCENE POINT ELLEN FORMATION AND BURNHAM LIMESTONE, SOUTH AUSTRALIA

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Summary

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Mollusca of the Point Ellen Formation and Burnham Limestone are recorded and two new species, *Nerita milnesi* and *Linga (Bellucina) praetermissa*, are described from the Point Ellen Formation. Both formations overlie the Hallett Cove Sandstone or its equivalents. An Early Pleistocene age is indicated from the presence of several species described from the Roe Calcarenite, including the pelagic janthinid *Hartungia dennanti chavani*. The Burnham Limestone is considered to be a lateral equivalent of the Point Ellen Formation. Its impoverished fauna contains *Monilea euclensis*, otherwise known only from the Point Ellen Formation and the Roe Calcarenite. The relevance of the age of the faunas to the age of tectonic warping on Fleurieu Peninsula and Kangaroo Island is discussed.

KEY WORDS: Mollusca, Early Pleistocene, Point Ellen Formation, Burnham Limestone, new species, Kangaroo Island, Fleurieu Peninsula, tectonism.

Introduction

The Point Ellen Formation and its lateral equivalent the Burnham Limestone are thin remnants of carbonate sediments laid down in the Early Pleistocene during a regressive phase which followed a more extensive marine transgression during the Late Pliocene (Ludbrook 1954, 1959). Both formations are of limited extent, at present known to crop out only on the south coast of Kangaroo Island, the eastern side of Gulf St Vincent south of Adelaide and possibly on the Murray River at Tailem Bend. They were deposited on irregular surfaces and vary in thickness from a few centimetres to two metres. At Point Reynolds, Port Willunga and Maslin Bay they occur in sequence above the Hallett Cove Sandstone or its equivalents. Their relative heights above sea level have an important bearing on refining the age of the gentle tectonic folding in the Kangaroo Island-Fleurieu Peninsula elevated zone (Glaessner & Wade 1958).

The richly fossiliferous limestone at Point Ellen on Kangaroo Island has been known since 1914 when, as part of a survey of supposed oil-bearing areas of South Australia, Arthur Wade made the first collection of fossils from the outcrop. Wade's material was sent to Chapman at the National Museum of Victoria for identification and an annotated list of species of foraminifera and Mollusca was published by Chapman in an Appendix to Wade (1915).

Small collections were made by H. Wopfner in 1964 and A. R. Milnes and B. J. Cooper in 1980. The full significance of the fauna was not recognised until the molluscs were more selectively collected by Milnes, Cooper and Ludbrook in 1981 and by Milnes and Ludbrook in 1982.

Chapman recorded, under the following names and with brief annotations, twelve species: *Glycimeris subardians* Tate (in Basedow), *G. australis* Quoy & Gaimard sp. var. *gigantea* var. nov., *Dosinea* cf. *victoriae* Gatliff & Gabriel, *Tellina basedowi* Tate, *Mactra ovalina* Tate, *Turbo stamineus* Martyn, *Natica conica* Lamarck, *Diastoma* sp., *Lotorium verrucosum* Reeve sp., *Voluta (Amoria) undulata* Lamarck sp., *Ancilla* cf. *petterdi* Tate sp. and *Cancellaria granosa* Sowerby.

From recent collecting the fauna has now been increased to 51 species. In the much abridged synonymies of the species accounts Chapman's nomenclature has been included and most of the specimens figured.

The Burnham Limestone was named and described by Firman (1976). Little attention has so far been paid to its small fauna and it is likely that, prior to Brian Daily's sampling of the formation at Maslin Bay in 1966, any specimen collected from the Burnham Limestone was included in the fauna of the Hallett Cove Sandstone. Daily's bulk sample was examined as such by Ludbrook without re-

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covering or naming any of the contained species. It was suggested that the unit might be correlated with sands containing small molluscs occurring at depth at Lockleys and shown on a correlation chart as equivalent to the Pleistocene Calabrian Stage (Ludbrook 1963; Twidale *et al.* 1967). The Hallett Cove Sandstone and Dry Creek Sands were later stated to pass vertically into poorly fossiliferous Lower Pleistocene calcareous or quartz sands in places (Ludbrook 1969). The units were not included in the Cenozoic correlation chart (Ludbrook 1973).

Daily's samples from Maslin Bay and O'Sullivan Beach have now been critically examined, together with material collected by J. M. Lindsay and by Firman and Ludbrook from Firman's supplementary section at Port Willunga. Nine molluscan species are recognised, of which the most important for purposes of correlation is *Monilea euclensis* Ludbrook, described from the Roe Calcarenite and occurring also in the Point Ellen Formation.

Whether they overlie the Hallett Cove Sandstone or not, both the Point Ellen Formation and the Burnham Limestone can be distinguished lithologically from the Late Pliocene Hallett Cove Sandstone by their relative friability and by being less affected by diagenesis. On Kangaroo Island in particular, the Hallett Cove Sandstone is either hard and dense or considerably leached and ferruginised; except at Point Reynolds, the Point Ellen Formation is more porous, less leached and much original shell material is preserved. The matrix may be a soft carbonate rock from which the molluscs weather out readily, as at Cape Jervis. The Burnham Limestone is mostly a soft, powdery, rubbly carbonate rock. Both formations are often affected by surface calcrete.

The extent and tectonic implications of the Point Ellen Formation and Burnham Limestone

The Point Ellen Formation was defined by Milnes *et al.* (1983). At present it is known from four exposures only: the type section at Point Ellen at the southwestern entrance to Vivonne Bay, at "Table Rock", Point Reynolds, at the southwestern end of Pennington Bay and Cape Willoughby at the southeastern extremity of Kangaroo Island, and, northerly from Cape Willoughby, at Cape Jervis on Fleurieu Peninsula on the eastern side of Backstairs Passage (Fig. 1).

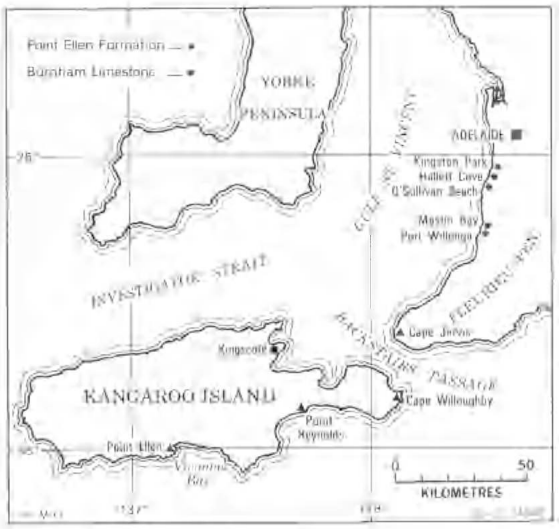


Fig. 1. Locality map.

At "Table Rock", Point Reynolds, the Point Ellen Formation is interbedded with cross-bedded aeolianites near the base of the Bridgewater Formation overlying Late Pliocene limestone. Like the underlying Late Pliocene, the Point Ellen Formation is considerably leached, but it contains *Nerita milnesi*. The boulder from Point Reynolds (GSSA F20/55) formerly thought to have come from the Pliocene is now known to have been derived from the Point Ellen Formation at that locality. It contains *Monilea euclensis*.

Subsequent to its deposition, the Point Ellen Formation has been gently displaced by warping and possibly also by faulting. At Cape Jervis, the base is 50 m above sea level, at Cape Willoughby and Table Rock 10 m above, and at Point Ellen less than 10 m. This gentle warping of less than 1° is considered to be due to reactivation during the Pleistocene of early Palaeozoic tectonic movements in the area, shown by Thomson & Horwitz (1962), and forms part of the broad structural trend from Fleurieu Peninsula to Kangaroo Island (Glaessner 1953).

The Burnham Limestone occurs as thin discrete remnants cropping out south of Adelaide in the sea cliffs or near the coast between Kingston Park and Port Willunga. The most accessible exposure of the Burnham Limestone is in the old boat ramp at Port Willunga, the supplementary section of Firman (1976). Its height above sea level decreases from 30 m at Hallett Cove to 20 m at Maslin Bay. In Aldinga and Maslin Bays the Burnham Limestone conformably overlies the Hallett Cove

Sandstone, and in the southern part of Maslin Bay, where both formations thin out in a northerly direction, the Burnham Limestone persists beyond the northern limit of the Hallett Cove Sandstone. Both formations have a gentle southerly dip of about 1°.

The Burnham Limestone has also been interpreted in bores in the Adelaide Plains Subbasin as thin patches or lenses of marly limestone overlying a karst surface of the Hallett Cove Sandstone and below the Hindmarsh Clay (Lindsay 1969, Firman 1976, Selby & Lindsay 1982) from Port Gawler southwards, some 52–62 m below sea level on the downthrow side of the Para Fault.

A carbonate sediment containing scattered small gastropods at Jervois punt landing, Tailem Bend, on the Murray River, may possibly be correlated with the Burnham Limestone, but fossil evidence is insufficient.

An outcrop of Hallett Cove Sandstone was formerly exposed at an elevation of 100 m above sea level about 0.5 km east of the type section of the Hallett Cove Sandstone. Although this was mapped (Sprigg 1942) as "Pleistocene raised beach", the only material collected from the outcrop by Ludbrook and Steel in 1960 belongs to the Hallett Cove Sandstone. No Burnham Limestone was seen, although a remant occurs about 30 m above sea level near the amphitheatre at Hallett Cove. The difference in elevation of some 60° of the Hallett Cove Sandstone east of Hallett Cove appears to be due to warping rather than faulting at this locality.

The fauna of the Point Ellen Formation

The molluscan fauna is essentially that of a bay with rocky headlands on an exposed coast. A new species, here described as *Nerita milnesi*, is apparently restricted to the formation and is present in considerable numbers. Most nerites live gregariously on rocks in the intertidal zone, although some are adapted to estuarine or even freshwater habitats. Shells of the associated pelagic janthinid gastropod *Hartungia dennanti chavani* have been concentrated with the nerites by on-shore winds in a similar manner to those found in the Roe Calcarenite. The rest of the fauna is an assemblage of both rock-dwelling species and intertidal species of a sandy bay. Of the 51 species, six are restricted to the Early Pleistocene, nine do not occur above the Early Pleistocene and 36 are still living.

Associated with the molluscs is a small assemblage of foraminifera consisting mostly of *Marginopora vertebralis* and *Ammonia beccarii* with *Elintina triquetra*, *Cribrobulimina polystoma*, *Elphidium rotatum* and *Peneroplis* sp. cf. *P. pertusus*.

BIVALVIA

GLYCYMERIDIDAE

Glycymeris (Tucetilla) radians (Lamarck) Cape Willoughby (1)

Pectunculus radians Lamarck, 1819: 54

A living species recorded from the Late Pliocene and Early Pleistocene.

Glycymeris (Tucetona) convexa (Tate) FIG. 2e. Cape Jervis (1)

Pectunculus convexus Tate, 1886: 138, pl. 11, figs 7a,b

Type locality: Muddy Creek, Victoria, Grange Burn Coquina, Early Pliocene. Tate's type series includes specimens from Norwest Bend Formation and Hallett Cove Sandstone. The species is common in the Dry Creek Sands.

Glycymeris (Veletuceta) pseudaustralis Singleton FIG. 2c,d. Cape Jervis (1)

Glycymeris (Veletuceta) pseudaustralis Singleton, 1941: 425, pl. 20, figs 4, 5

Type locality: Werrikoo Limestone, Glenelg River at Roscoe's, Parish of Killara, Victoria.

PECTINIDAE

Chlamys (Chlamys) asperrima asperrima (Lamarck) Cape Jervis (fragment)

Pecten asperrimus Lamarck, 1819: 174

A common living species present in the Roe Calcarenite.

Chlamys (Chlamys) asperrima (?) dennanti Gatliff & Singleton Cape Willoughby (3 fragments)

Chlamys asperrimus dennanti Gatliff & Singleton, 1930: 73, pl. III, figs 8,9; pl. IV, figs 3a,b

Type locality: Glenelg River above Limestone Creek, Victoria, Werrikoolan.

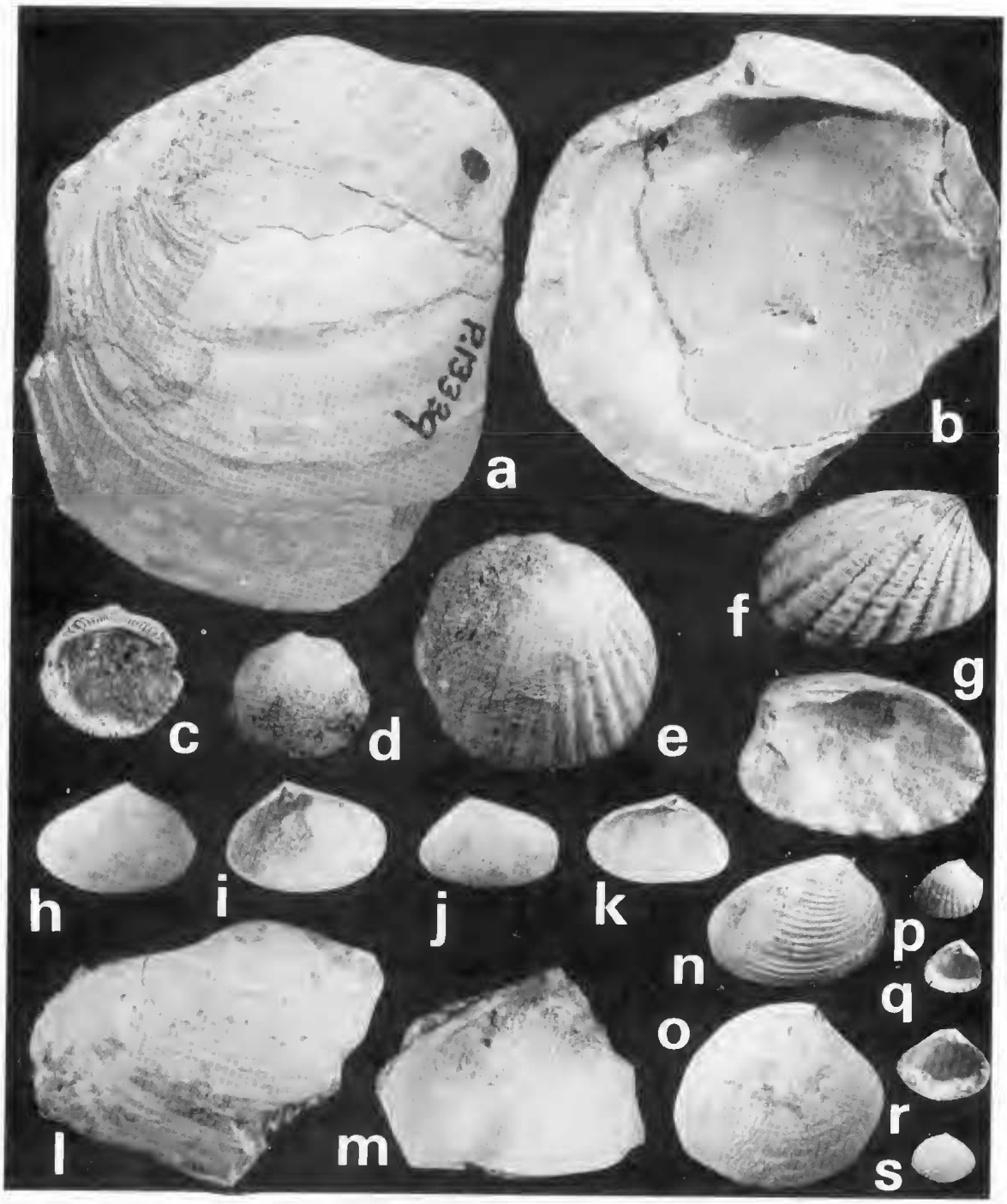
The material is fragmentary and the identification of the sub-species open to doubt. If confirmed, it provides a useful correlation with the Werrikoo Limestone.

OSTREIDAE

Ostrea sp. cf. *Ostrea angasi glenelgensis* Singleton Cape Willoughby (1 fragment), Cape Jervis (1 fragment)

Ostrea angasi Sowerby; Tate, 1887a: 110

Ostrea similata glenelgensis Singleton, 1941: 426, pl. 20, fig. 6



Two fragments of valves of a rounded species with a straight dorsal margin, long hinge and large muscle scar appear to belong to the subspecies, described from the basal shell bed of the Werrikoo Limestone and recorded as occurring at a higher level with *Pecten meridionalis*, i.e. Late Pliocene to Early Pleistocene.

LUCINIDAE

Anodontia sphericula (Basedow) FIG. 2a
Point Ellen (5)

Meretrix sphericula Basedow, 1902: 131, pl. 2, fig. 2

Glycymeris australis Quoy & Gaimard sp. var. *gigantea* Chapman, 1915: 49; Chapman & Singleton, 1925: 47, pl. III, fig. 32; pl. IV, fig. 22

Anodontia sphericula (Basedow) Ludbrook, 1959: 227, pl. 3, figs 1-3, pl. 5, figs 1-4; 1973: pl. 26, fig. 65; 1978: 52; pl. 5, fig. 1

Singleton (1941, 426) noted that the holotype of *Glycymeris australis* var. *gigantea* (here refigured) was, in his opinion, not a glycymerid but a lucinid.

The species has a long range from Miocene to Early Pleistocene.

Miltha hamptonensis Ludbrook FIG. 2b Point Ellen (6), Cape Jervis (1)

Dosinia cf. *victoriae* Chapman, 1915: 49, *non* Gatliff & Gabriel

Miltha hamptonensis Ludbrook, 1969: 60, pl. 3, figs 1-3; pl. 4, figs 1,2

Otherwise known only from the Roe Calcarenite.

?Callucina lacteola (Tate)

Lucina lacteola Tate, 1897: 48 *nom. nov.* for *Lucina lactea* Adams *non* Lamarck.

A mould in limestone from Point Reynolds may be referred to this living species which occurs also in the Roe Calcarenite.

Genus *Linga* de Gregorio, 1884
Subgenus *Bellucina* Dall, 1901

Linga (Bellucina) praetermissa sp. nov.

FIG. 3a–d

Bellucina crassilirata Macpherson & Gabriel, 1962: 327, fig. 372, *non* Tate, 1887

Material: Holotype GSSA 10020 and two paratypes GSSA 10021 Point Ellen Formation, Point Ellen; numerous valves SAM labelled "*Lucina crassilirata* Tate, Kenyon Collection, probably Victoria". The uncertainty of the locality precludes selection of types from the Victorian material.

Shell small, solid but only moderately thick, globose, subequilateral, rounded anteriorly, posteriorly truncated, with an umbonal-ventral flexure, margin sinuated at flexure; sculpture variable, predominantly of fine concentric lirae, interrupted by deep growth channels; radial sculpture variable or absent, consisting of fine threads crossing interspaces between the concentric lirae; inner margin finely crenulate. Hinge of moderate width, cardinals oblique with triangular pit between them, LV with 4b narrow, high, 2 triangular, short, PII, PIV, AII, AIV all short; RV with small 3a, triangular somewhat bifid 3b, short AI, AIII, PI, and PIII. Holotype height 7, width 7 mm; paratype (locality "Victoria") height 10, width 10 mm.

The species figured by Macpherson & Gabriel as *Bellucina crassilirata* was stated to be seen frequently at Western Port.

CARDITIDAE

Cardita subdeceptiva Ludbrook FIG. 2f,g Cape Jervis (3)

Cardita subdeceptiva Ludbrook, 1955: 40, pl. 4, fig. 14

Known also from the Dry Creek Sands and the Late Pliocene of Gum Creek, K.I.

Pleuromeris subpecten Ludbrook FIG. 2p,q Cape Jervis (2)

Pleuromeris subpecten Ludbrook, 1955: 42, pl. 2, fig. 3

Described from the Dry Creek Sands

MACTRIDAE

Mactra sp. cf. *Mactra pura* Deshayes

Mactra pura Deshayes, 1853: 15

An internal cast of a *Mactra*, similar in shape to *M. pura*, recorded (Ludbrook 1978) from Early Pleistocene to Holocene.

MESODESMATIDAE

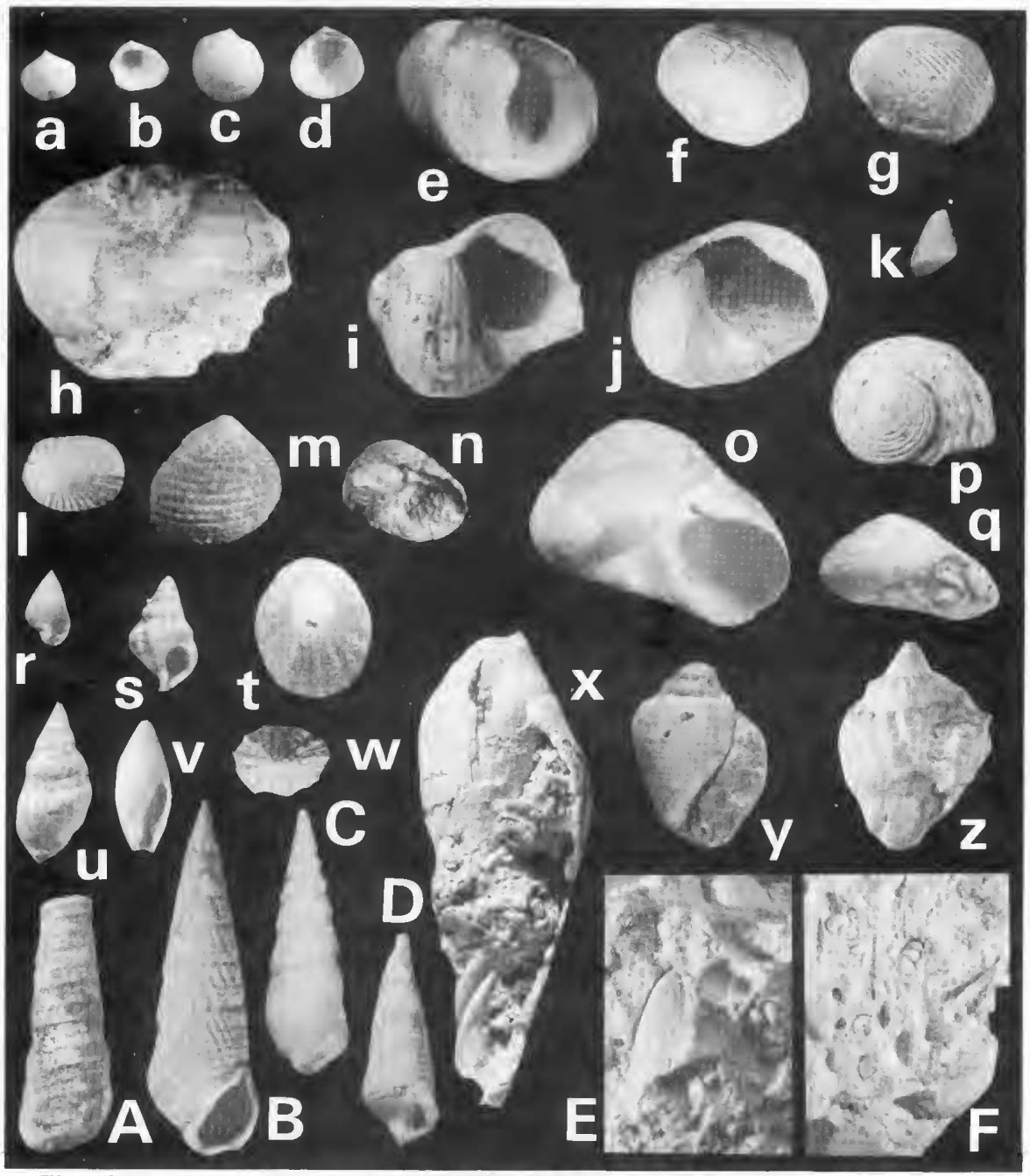
Amesodesma angusta (Reeve) FIGS 2j,k Point Ellen (3)

Mesodesma angusta (Reeve) 1854 pl. 1, fig. 3

Occurs rarely in the Point Ellen Formation and, like *A. cuneata*, has a continuous record on Kangaroo Island from the Early Pleistocent to the present.

Fig. 2, a, *Anodontia sphericula* (Basedow), holotype of *Glycimeris australis gigantea* Chapman NMV P13339; b, *Miltha hamptonensis* Ludbrook GSSA 10009; c,d, *Glycymeris (Veletuceta) pseudaustralis* Singleton c, interior, d, exterior GSSA 10010; e, *G. (Tucetona) convexa* (Tate) GSSA 10011; f,g, *Cardita subdeceptiva* Ludbrook RV f, exterior, g, interior GSSA 10012; h,i, *Amesodesma cuneata* (Lamarck) LV h, exterior, i, interior GSSA10013; j,k, *Amesodesma angusta* (Reeve) RV j, exterior, k, interior GSSA 10014; l,m, *Tellina* sp. (*Mactra ovalina* of Chapman) GSSA 10015; n, *Katelysia scalarina* (Lamarck) GSSA 10016; o, *Gafrarium pecornatum* Woods GSSA 10017; p,q, *Pleuromeris subpecten* Ludbrook GSSA 10018;r, s, *Timoclea (Veremolpa) kendricki* Ludbrook LV r, interior, s, exterior GSSA 10019. All natural size and all from Point Ellen except m,n,r,s from Cape Jervis.

GSSA, Geological Survey of South Australia; NMV, National Museum of Victoria; SAM, South Australian Museum



The subgenus *Amesodesma* is here accorded full generic status, details of which are discussed in a paper in preparation.

Amesodesma cuneata (Lamarck) FIG. 2h,i. Point Ellen (3)

Crassatella cuneata Lamarck 1818: 483

Specimens from Point Ellen are identical with living specimens from Kingscote and with those occurring in the St Kilda Formation of the coast road, Bay of Shoals. The species is more common on Kangaroo Island than the smaller, narrower *A. angusta.*

TELLINIDAE

Tellina sp. FIG. 2o,p. Point Ellen (3)

Mactra ovalina Lamarck. Chapman 1915: 49, *non Mactra ovalina* Lamarck

The specimens identified as *Mactra ovalina* are in the Palaeontology Collection of the Geological Survey of South Australia, together with another specimen collected by H. Wopfner in 1964. With two exceptions, they are firmly embedded in hard matrix and the hinges are obscured. Although in shape and size they are comparable with the New Zealand *Longimactra elongata* (Quoy & Gaimard), no suggestion of a mactrid hinge can be seen. There is a long external ligament pit and a supporting nymph; such of the pallial line as is visible appears to have a fairly deep sinus. The species is therefore probably a large *Tellina* with rather convex valves.

VENERIDAE

Katelysia scalarina (Lamarck) FIG. 2l Point Ellen (7), Point Reynolds (moulds), Cape Willoughby (mould)

Venus scalarina Lamarck, 1818: 599

Not uncommon in the formation, as in the Roe Calcarenite and throughout the Pleistocene to the present.

Timoclea (Veremolpa) kendricki Ludbrook FIG. 2r,s. Point Ellen (1), Cape Willoughby (1)

Timoclea (Veremolpa) kendricki Ludbrook, 1978: 80, pl. 9, figs 9-12, 15, 16.

Described from the Roe Calcarenite.

Gafrarium pervornatum Woods FIG. 2q Point Ellen (1)

Gafrarium pervornatum N. H. Woods, 1931: 148, pl. 7, figs 7, 8

Occurs in the Dry Creek Sands and is otherwise known only from Point Ellen.

SCAPHOPODA

DENTALIIDAE

Dentalium latesulcatum Tate Cape Jervis (1)

Dentalium latesulcatum Tate, 1899: 262, 267, pl. 8, fig. 9

Has a range of Early Pliocene to early Pleistocene.

GASTROPODA

HALIOTIDAE

Haliotis (Exohaliotis) cyclobates Peron & Lesueur Point Ellen (2 fragments)

Haliotis cyclobates Peron & Lesueur, 1816: 80

Found also in the Roe Calcarenite but otherwise known only from the modern fauna.

FISSURELLIDAE

Clypidina (Montfortula) rugosa (Quoy & Gaimard) FIG. 3l Point Ellen (1), Cape Jervis (1)

Emarginula rugosa Quoy & Gaimard, 1834: 331, pl. 68, figs 17, 18

Previously known only from the modern fauna.

ACMAEIDAE

Patelloida nigrosulcata (Reeve) Point Ellen (1)

Patella nigrosulcata Reeve, 1855: pl. 30, fig. 84

First appears in the Point Ellen Formation and continues through the Glanville and St Kilda Formations to the present day, when it is commonly found attached to *Patella (Scutellastra) laticostata* Blainville.

PATELLIDAE

Patella (Scutellastra) peronii Blainville FIG. 3t, Cape Jervis (2)

Patella peronii Blainville, 1825: 111

Known only from Cape Jervis and the modern fauna.

TROCHIDAE

Cantharidus (Phasianotrochus) eximius (Perry) Point Ellen (3)

Bulimus eximius Perry, 1811: pl. 30, fig. 20

Previously known only from the modern fauna.

Fig. 3. a-d. *Linga (Bellucina) praetermissa* sp. nov. a,b. holotype LV a. exterior, b. interior GSSA 10020, c,d. Kenyon specimen SAM RV c. exterior, d. interior; e-g. *Nerita milnesi* sp. nov. e. holotype apertural view GSSA 10022, f,g. paratypes showing variation in ribbing GSSA 10023; h-j. *Hartungia dennanti chavani* Ludbrook GSSA 10025 a,b,c; k. *Cantharidus (Phasianotrochus) apicinus* (Menke) GSSA 10026; l. *Clypidina (Montfortula) rugosa* (Quoy & Gaimard) GSSA 10027; m,n. *Diloma (Fractarmilla) concamerata* (Wood) GSSA 10028; o. *Diloma (Fractarmilla) rudis* (Gray) GSSA 10029; p,q. *Monilea euclensis* Ludbrook p. apical view GSSA 10030, q. apertural view GSSA 10031; r. *Niotha pyrrhus* (Menke) GSSA 10032; s. *Cymatiella verrucosa* (Reeve) Chapman specimen GSSA 10033; t. *Patella (Scutellastra) peronii* Blainville GSSA 10034; u. *Cominella eburnea* (Reeve) GSSA 10035; v. *Amalda (Gracilispira) monilifera* (Reeve) GSSA 10036; w. *Siphonaria (Hubendickula) baconi* Reeve GSSA 10037; x. *Amoria (Amoria) gravi* Ludbrook GSSA 10038; y. *?Austroharpa kendricki* Ludbrook GSSA 10039; z. *Sydaphera undulata* (Sowerby) GSSA 10040; A. *Gazameda iredalei* Finlay GSSA 10041; B. *Diastoma adelaidense* Ludbrook GSSA 10117; C. *D. melanioides* (Reeve) GSSA 10042; D. *Batillaria (Zeacumantus) diemenensis* (Quoy & Gaimard) GSSA 10043; E. Burnham Limestone with cast of *?Brachidontes* sp. cf. *B. suberosus* (Singleton) GSSA 10044; F. Burnham Limestone with moulds and casts of *Batillaria (Batillariella) estuarina* (Tate) GSSA 10045. All natural size and from Point Ellen except k,q,y, E and F from Burnham Limestone.

Diloma (Fractarmilla) concamerata (Wood) FIG. 3m,n. Point Ellen (5), Cape Jervis (29)

Trochus concamerata Wood, 1828: 17, pl. 6, fig. 35

The earliest record is in the Point Ellen Formation; it continues through the Glanville and St Kilda Formations to the present day.

Diloma (Fractarmilla) rudis (Gray) FIG. 3o. Point Ellen (1)

Monodonta rudis Gray, 1827: 480

Occurs rarely in the Point Ellen and Glanville Formations of Kangaroo Island and in the modern fauna west from Gulf St Vincent to Western Australia where it is common.

Monilea euclensis Ludbrook FIG. 3p,q. Point Ellen (3), Cape Jervis (2)

Monilea euclensis Ludbrook, 1978: 97, pl. 10, figs 4-8, 12

Described from the Roe Calcarenite where it is common; elsewhere known only from the Point Ellen Formation where it appears to be not uncommon, and the Burnham Limestone.

TURBINIDAE

Turbo (Ninella) torquatus Gmelin. Point Ellen (2), Cape Jervis (1)

Turbo torquatus Gmelin, 1791: 3597, No. 106
Turbo stamineus Martyn. Chapman, 1915: 49 (Martyn name rejected ICZN 456)

The three small examples are the earliest certain record of the species which continues through uncommon occurrences in the Glanville Formation to the present day.

Astraea (Micrastraea) aurea (Jonas) Point Ellen (1).

Trochus aureus Jonas, 1845: 168

The living species occurs also in the Glanville Formation on Kangaroo Island.

Astraea (Micrastraea) rutidoloma (Tate) Cape Jervis (3)

Turbo (Astrallium) rutidoloma Tate, 1893: 192, pl. 1, fig. 9

Common in the Roe Calcarenite but not so far recorded from the Late Pleistocene; living.

NERITIDAE

Genus *Nerita* Linnaeus, 1758

Nerita milnesi sp. nov.

FIG. 3e–g.

Material: holotype GSSA 10022 and paratypes GSSA 10023, 10024 61 topotypes Point Ellen, 1 specimen and 3 fragments Cape Willoughby, 65 specimens Cape Jervis.

Shell rather small, globose, solid, thick, spire flat, almost obliquely planispiral, (the inner walls of Neritidae being resorbed), protoconch flat, usually eroded, 1–1½ adult whorls, the last whorl almost enveloping the rest of the shell; surface of shell sculptured with 24–27 spiral ribs with linear grooves between them. Ribs generally light coloured and grooves black, protoconch smooth and white. Aperture semicircular, outer lip crenulated by spiral ribs, widely thickened with posterior denticle and anterior denticle set on inner margin of lip, inner lip septum or "deck" well developed, smooth and shining with three denticles in the middle.

Dimensions: holotype height 12, diameters 23 and 18 mm; large paratype height 16, diameters 24 and 20 mm.

The species resembles most closely *Nerita lineata* from northwest and northern Australia. It is only about half the size of *lineata*, which is generally more finely ribbed and somewhat more variable than *N. milnesi*, specimens from Exmouth being closer to *N. milnesi* than those from the north. It is extremely abundant in the cliff face at Point Ellen, forming a coquinite in places, and was no doubt living gregariously on rocks in the intertidal zone like its modern counterparts. It has gone unnoticed in the past, with the exception of a reference to "Reef shell beds (*Turbo* etc.) at the base of the aeolianite system" in the Pleistocene section of the legend to the KINGSCOTE 4-mile geological series map (Sprigg 1954).

The species is named for Dr A. R. Milnes.

PHASIANELLIDAE

Phasianella angasi Crosse

Phasianella angasi Crosse, 1864: 344, pl. 13, fig. 5

A single specimen was found at Point Ellen and a doubtful specimen in the Holocene at Point Tinline. Modern distribution of the species is from Western Australia to South Australia.

Phasianella australis (Gmelin) Point Ellen (9)

Buccinum australe Gmelin, 1791: 3490, No. 173

Appears to be common in the Point Ellen Formation as it is in the Roe Calcarenite. Its first known occurrence is in the Late Pliocene at Gum Creek and it persists through the Glanville Formation to the present day.

LITTORINIDAE

Bembicium melanostoma (Gmelin) Point Ellen (2)

Trochus melanostomus Gmelin, 1791: 3581

Has a continuous record from the Early Pleistocene to the present day, when it lives mostly in sheltered rocky bays or on mud flats.

Bembicium nanum (Lamarck) Cape Jervis (9)

Trochus nanum Lamarck, 1822b: 30

Has an irregular record in the Quaternary. It occurs in the Roe Calcarenite and in the Glanville and St Kilda Formations on Kangaroo Island. It is a modern inhabitant of rocks on open coast.

POTAMIDIDAE

Batillaria (Zeacumantus) diemenensis (Quoy & Gaimard) FIG. 3D, Point Ellen (21)

Cerithium diemenense Quoy & Gaimard, 1833: Atlas pl. 55, figs 11-13; 1834: 128.

Occurs more or less abundantly from the Late Pliocene of the Dry Creek Sands to the present day.

TURRITELLIDAE

Gazameda iredalei Finlay FIG. 3A, Point Ellen (3)

Gazameda iredalei Finlay, 1927: 496.

First appears in the Dry Creek Sands, very common in the Roe Calcarenite and continuing through the Glanville Formation and St Kilda Formation to the present day.

DIASTOMATIDAE

Diastoma adelaidense Ludbrook FIG. 3B, Point Ellen (6)

Diastoma adelaidense Ludbrook, 1971: 32, pl. 1, figs 3-7, pl. 6, figs 9, 10.

Diastoma melanioides (Reeve) FIG. 3C, Point Ellen (13), Point Reynolds, Cape Willoughby (moulds)

Mesalia melanioides Reeve, 1849: pl. 1, fig. 1.
Diastoma sp. Chapman 1915: 49

Chapman noted that the *Diastoma* in Wade's material was closely related to *D. provisi* Tate from Hallett Cove and the Dry Creek Bore; both *D. adelaidense* and *D. melanioides* are present, however, as they are also in the Roe Calcarenite.

CERITHIIDAE

Diala lauta A. Adams Point Ellen (2)

Diala lauta A. Adams, 1862: 298

This is a ubiquitous small species throughout the Quaternary, although uncommon at Point Ellen where the environment would have been rather unfavourable. It lives today on algae in sheltered inlets and bays.

Campanile symbolicum Iredale Point Ellen (1)

Campanile symbolicum Iredale, 1917: 326 *nom. nov.* for *Cerithium leve* Quoy & Gaimard, 1833 *non Cerithium laevis* Perry, 1810

Represented in the Point Ellen Formation by a single specimen embedded in hard matrix with coral. This is as far east as the species has been found. It is common in the Roe Calcarenite and in the modern Western Australian fauna.

JANTHINIDAE

Hartungia dennanti chavani FIG. 3h-j, Point Ellen (17), Cape Jervis (4)

Hartungia dennanti chavani Ludbrook, 1978: 119, pl. 12, figs 1-14

From a stratigraphic point of view, this is the most diagnostic and important species in the Point Ellen Formation. It is a pelagic gastropod with a limited range, found abundantly in the Roe Calcarenite. In the Point Ellen Formation it was probably brought in by on-shore winds and deposited in some abundance with *Nerita* at the type section.

HIPPONICIDAE

Hipponix (Sabia) conicus (Schumacher), Point Reynolds (moulds), Cape Jervis (1)

Amalthea conica Schumacher, 1817: 181, pl. 21

Represented by a single specimen only from Cape Jervis. It has a range of Late Pliocene to the present.

Hipponix (Antisabia) erma (Cotton), Point Ellen (1), Point Reynolds (mould), Cape Jervis (1)

Sabia (Antisabia) erma Cotton, 1939: 171, pl. 7, fig. 8

Described from Reevesby Island. The specimen from Point Ellen is small with somewhat granulose concentric laminae approaching the sculpture of *H. (A.) foliaceus*. However, in both this specimen and the more typical example of *H. (A.) erma* from Cape Jervis, as well as the mould from Point Reynolds, the apex nearly overhangs the margin. Also occurs in the Glanville Formation.

NATICIDAE

Polinices (Conuber) conicus (Lamarck) Point Ellen (1)

Natica conica Lamarck, 1822a: 198
Natica conica Lamarck, Chapman 1915: 49

The species has an almost continuous record from the Late Pliocene to the present.

CYMATIIDAE

Cymatiella verrucosa (Reeve) FIG. 3s, Point Ellen (11)

Triton verrucosus Reeve, 1844: pl. 17, sp. 71
Lotorium verrucosum Reeve sp. Chapman, 1915: 49

The record is limited to the single specimen identified by Chapman; it is a living species occurring also in the Glanville and St Kilda Formations.

BUCCINIDAE

Cominella eburnea (Reeve) FIG. 3u. Point Ellen (5)

Buccinum costatum Quoy & Gaimard, 1833: 417, pl. 30, figs 17-26 (*non* Linnaeus, 1758, *nec* Da Costa 1778, *nec* Meuschen, 1787) *Buccinum eburneum* Reeve, 1846: sp. 31, pl. 12, fig. 93

Represented continuously from the Point Ellen Formation and Roe Calcarenite to the present day.

NASSARIIDAE

Niotha pyrrhus (Menke) FIG. 3r. Point Ellen (3)

Buccinum pyrrhus Menke, 1843: 21

Has a continuous record from the Roe Calcarenite and Point Ellen Formation to the present.

OLIVIDAE

Amalda (Gracilispira) monilifera (Reeve) FIG. 3v. Point Ellen (24)

Ancillaria lineata Kiener, 1844: 16, pl. 3, fig. 2 *non Ancilla lineata* Perry, 1811
Ancillaria monilifera Reeve, 1864: v.10, figs 36a,b
Ancilla cf. petterdi Tate sp. Chapman 1915: 50

This living species is common in both the Roe Calcarenite and Point Ellen Formation but is not known so far from the Late Pleistocene.

VOLUTIDAE

Amoria (Amoria) grayi Ludbrook FIG. 3x. Point Ellen (1)

Voluta pallida Gray, 1834: pl. 30, fig. 4, Index p. 601 (*non Voluta pallidus* Linnaeus, 1767)
Voluta (Amoria) undulata Chapman, 1915: 50 (*non Voluta undulata* Lamarck)
Amoria (Amoria) grayi Ludbrook, 1953 *nom. nov.* for *Voluta pallida* Gray *non* Linnaeus not *Amoria grayi* Daily *et al.* 1976

Chapman recorded two species of *Voluta (Amoria) undulata* having considerable variation in the height of the spires. Only the specimen figured here is in the GSSA collection and although it is incomplete it can be fairly reliably compared with *Amoria (Amoria) grayi*. It has no trace of the undulose linear surface ornament of *undulata* noted by Chapman. The specimen figured by Daily *et al.* (1976, fig. 21b) as *Amoria grayi* is not that species but a specimen in the Tate Museum, University of Adelaide, identified as *Amoria masoni* (Tate).

A. (A.) grayi was recorded also from the Dry Creek Sands and the Roe Calcarenite. It is a common variable species with a modern range from Geographe Bay to Cambridge Gulf, W.A.

CANCELLARIIDAE

Sydaphera undulata (Sowerby) FIG. 3z. Point Ellen (1)

Cancellaria granosa Sowerby, 1832: pl. 10, fig. 16 (not pl. 10, fig. 17)
Cancellaria undulata Sowerby, 1848: 136
Cancellaria granosa Sowerby, Chapman, 1915: 50

Only one of the two specimens recorded by Chapman is in the GSSA Collection. Rare in the Point Ellen Formation and the Roe Calcarenite and is not known again before its present occurrence from southwestern Australia to Victoria.

CONIDAE

Conus sp. Cape Willoughby (1)

An internal cast of an unidentified *Conus* embedded in matrix occurs at Cape Willoughby.

SIPHONARIIDAE

Siphonaria (Hubendickula) baconi Reeve FIG. 3w. Point Ellen (1)

Siphonaria baconi Reeve, 1856: pl. 6, sp. 30

A single specimen was found among the material examined by Chapman.

Has a continuous range in South Australia from the Point Ellen Formation to the present.

The fauna of the Burnham Limestone

The Burnham Limestone contains molluscan species most of which are intertidal inhabitants of estuaries, tidal inlets, or the sandy or muddy flats of sheltered bays. The small assemblage is dominated by *Batillaria (Batillariella) estuarina* and *Anapella variabilis*, with *Chlamys (Equichlamys) bifrons subbifrons*, *Brachidontes* sp. cf. *B. suberosus*, *Limatula* sp. cf. *L. ludbrookae*, *Cantharidus (Phasianotrochus) apicinus*, *Monilea euclensis*, *Microcolus dunkeri* and *Austroharpa kendricki*.

Three species are restricted to Early Pleistocene deposits, one occurs also in the Late Pliocene and the rest are still living.

Marginopora vertebralis is also present.

BIVALVIA

PECTINIDAE

Chlamys (Equichlamys) bifrons subbifrons (Tate) Maslin Bay (1)

Pecten subbifrons Tate, 1882: 44; 1886: 104, pl. 3, fig. 2.

The specimen is poorly preserved but appears to belong to the subspecies.

MYTILIDAE

Brachidontes sp. cf. *B. suberosus* (Singleton) FIG. 3E. Maslin Bay (1)

Aulacomya suberosa Singleton, 1941: 427, pl. XX, fig. 7

Represented by an internal cast only, but the straight anterior margin, sharp ridge and acute beaks are clearly seen. The only other recorded occurrence is in the Werrikoo Limestone of Limestone Creek, Glenelg River, Western Victoria.

LIMIDAE

Limatula ludbrookae Buonaiuto Maslin Bay (1)

Limatula ludbrookae Buonaiuto, 1977: 28, figs 1, 10-11, 27-35

The only specimen found so far is an internal mould which has the distinctive high, narrow shape of the species. It has been known previously only from the Hallett Cove Sandstone and Dry Creek Sands.

MESODESMATIDAE

Anapella variabilis (Tate) Maslin Bay (common), Port Willunga (8)

Anapa variabilis Tate, 1887b: 172, pl. 17, figs 5a-b

Modern relatives of this species inhabit estuaries and shallow water. The species is abundant in patches in the Burnham Limestone, mainly in the form of internal casts. It has a range of Late Pliocene to Early Pleistocene.

GASTROPODA

TROCHIDAE

Cantharidus (Phasianotrochus) apicinus (Menke) O'Sullivan Beach (1)

Monodonta apicina Menke, 1843: 15

Rare in the Burnham Limestone, but occurs abundantly in the Roe Calcarenite and in the Holocene.

Monilea euclensis Ludbrook Hallett Cove (1), O'Sullivan Beach (1)

Monilea euclensis Ludbrook, 1978: 97, pl. 10, figs 4-8, 12

Known only from the Roe Calcarenite, Point Ellen Formation and the Burnham Limestone.

POTAMIDIDAE

Batillaria (Batillariella) estuarina (Tate) FIG. 3F Maslin Bay (abundant)

Bittium estuarinum Tate, 1893: 190, pl. 1, fig. 12

As the name implies, the species occurs in estuaries and tidal inlets. It is abundant in the Burnham Limestone at Maslin Bay. It has a continuous record from the Early Pleistocene to the present.

FASCIOLARIIDAE

Microcolus dunkeri (Jonas) Maslin Bay (1)

Fusus dunkeri Jonas, 1846: 129

Has a continuous record from the Early Pleistocene to the present, but is rare in the Burnham Limestone.

HARPIDAE

Austroharpa kendricki Ludbrook FIG. 3y. Hallett Cove (1)

Austroharpa kendricki Ludbrook, 1978: 162, pl. 18, figs 4-6

An internal cast from Hallett Cove appears to belong to the variety of the species with a denticulate outer lip (Ludbrook 1978, pl. 18, fig. 6) and a very low spire. The species is otherwise known only from the Roe Calcarenite. *Austroharpa* is well represented in the Tertiary of southern Australia and is still surviving off the coast today in relatively shallow water.

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